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2,808,327

METHOD OF DEOXIDIZING STEEL WITH ALUMINUM BASE ALLOY

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No Drawing. Application April 14, 1953, Serial No. 348,803

5 Claims. (Cl. 75-58)

This invention relates to steel making and, in particular, to the deoxidation practice in the making of killed, low-carbon steel intended specially for deep-drawing operations. The invention may, however, be applied also in making semi-killed or rimmed steel.

Conventional practice in making killed, low-carbon steel (under 0.15% carbon) involves the addition to the molten steel in the ladle of from three to six pounds of aluminum per ton of steel. For this purpose, it is customary to use low-grade aluminum such as that designated grade 4 in currently published reports of the market prices of non-ferrous metals, e. g., those found in the magazine "Iron Age." Grade 4 contains a minimum of 85% aluminum, the balance being made up of small percentages of several other metals present as impurities.

Killed low-carbon steel is particularly adapted by its physical properties for making sheet stock used in deep-drawing operations. Sheets rolled from low-carbon steel killed in the conventional manner, however, are subject to a high percentage of rejections caused by the presence of defects designated "slivers." These slivers are generally associated with patches of the aluminum added to the steel for the purpose of deoxidation, which remain segregated instead of dissolving in the steel and becoming uniformly distributed therein. Spectrographic analysis shows definitely that the aluminum content of the slivers is substantially higher than that of the surrounding metal. The slivers usually show up during rolling or final inspection but sometimes not until deep-drawing of the sheets in the customer's plant. In the latter case, the rejections entailed thereby represent a substantial loss, not only because of the cost of the material which must be scrapped, but also the added cost of shipping and handling and the labor and machine time consumed unproductively.

I have invented an improved practice for the deoxidation of steel whereby the occurrence of slivers in sheets rolled from the steel is materially reduced. Speaking generally, my invention contemplates the addition to molten steel of a deoxidizing agent composed largely of aluminum, which reacts therewith somewhat explosively and thus causes a more uniform distribution and solution of the aluminum. I have found that use of an alloy of aluminum containing zinc and magnesium within certain ranges, instead of commercial grade 4 aluminum, produces this result. This alloy is added to the molten steel while in the ladle or after it has been teemed into the ingot molds or the addition may be divided between the ladle and molds. Alternatively, it may be added to the stream in the spout from the furnace to the ladle as the tapping proceeds.

The percentages of zinc and magnesium in the alloy addition may vary between certain limits. The zinc may be from 3 to 5%, and the magnesium from 1.75 to 3%. Greater amounts make the reaction too violent while smaller amounts do not cause the desired distribution of the aluminum. The balance of the alloy is aluminum plus the impurities normally present in a commercial grade thereof. That is to say, the aluminum need not be of

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high purity. In fact, the residual metallic constituents (other than aluminum, zinc and magnesium) may be in the neighborhood of 10%. Preferably, the aluminum content is from 80 to 92% or more. The impurities in aluminum of this quality include iron, silicon and copper in amounts as high as 3% of each, as well as smaller amounts of manganese, lead, tin and molybdenum. Silicon is usually the largest impurity in low-grade aluminum. The silicon, of course, acts as a deoxidizer the same as the aluminum, and the presence of a substantial percentage thereof is unobjectionable. In fact, the low-grade aluminum which I prefer to employ in preparing my novel addition alloy may contain as much as 3.5% silicon.

The addition alloy described above may easily be made by adding to a commercial grade of aluminum such as grade 4, sufficient zinc and magnesium to provide the percentages thereof stated above, and fusing the metals together in accordance with known practice in making aluminum alloys. The following table gives the permissible ranges of the several elements and impurities (percentages by weight):

Table I

	Aluminum	Percent
	-----	80-92
25	Zinc	3-5

	Magnesium	1.75-3

	Impurities (e. g., silicon, copper, iron)	15.25-0

A preferred composition is given below (percentages by weight):

Table II

	Aluminum	Percent
	-----	85
	Zinc	4

35	Magnesium	2

	Impurities:	
	Silicon 3% approx.	9
	Copper 3% approx.	
	Iron 3% approx.	
40	-----	100.0

It is to be understood, of course, that, so long as 4% zinc and 2% magnesium are present, the remainder may be aluminum exclusively (i. e., up to 94%), but it is not necessary for the purpose of the invention to use pure aluminum in making the alloy addition and the use of low-grade aluminum is desirable because of its lower cost.

The addition agent is used in the same manner as aluminum is used at present for deoxidizing low-carbon steel. The steel is tapped from an open-hearth furnace, for example, at the desired carbon content, and the alloy of aluminum, zinc and magnesium is added to the steel in the ladle in the amount of from three to six pounds of alloy per ton of steel, preferably in the form of shot. A vigorous reaction approaching the character of a minor explosion ensues almost immediately. The explosive character of the reaction aids the distribution of the aluminum throughout the molten steel, increasing its deoxidizing efficiency and materially reducing the occurrence of slivers in the sheets rolled from the steel. In other words, the solution of the aluminum in the steel and its reaction therewith are more thorough than when low-grade aluminum of the usual composition is used, so that there is less chance for small masses of aluminum to remain segregated and cause slivers in the rolled sheets.

When the reaction is complete, the steel is killed and it is then cast into ingots which are subjected to conventional processing for the production of deep-drawing sheets. The rejection of such sheets because of the presence of slivers has been less than 1% compared to 6% or more for sheets of steel killed by the conventional deoxidizing agent. This obviously represents a substantial

saving on the large tonnages of low-carbon sheets used for deep-drawing.

While the invention is concerned particularly with the making of killed steel, the alloy addition disclosed herein may also be used for rimmed steel and semi-killed steel of carbon content up to 0.24%. The amount of the addition is less, however, being only about one ounce per ton, in order not to arrest the rimming action prematurely. This amount is preferably added to the molten steel after it has been teemed into the mold.

Although I have disclosed herein the preferred practice of my invention, I intend to cover as well any change or modification therein which may be made without departing from the spirit and scope of the invention.

I claim:

1. A method of making low-carbon steel comprising preparing a heat of such steel, and after tapping the heat, deoxidizing the steel while it is molten with a deoxidizing agent consisting essentially of from 3 to 5% zinc, from 1.75 to 3% magnesium and the balance substantially aluminum.

2. A method of making low-carbon steel comprising preparing a heat of such steel, and after tapping the heat,

deoxidizing the steel while it is molten with a deoxidizing alloy consisting essentially of about 4% zinc, about 2% magnesium, and the balance substantially aluminum.

3. A method as defined by claim 1 characterized by adding said agent in the amount of from three to six pounds per ton of steel.

4. A method as defined by claim 2 characterized by adding said alloy in the amount of from three to six pounds per ton of steel.

5. The method of deoxidizing steel comprising the steps of heating the steel to a molten state and then adding to the molten steel a deoxidizing alloy comprising at least 80% aluminum, about 3 to 5% zinc, and about 1.75 to 3% magnesium.

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